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No. 24—1911. (PART VI.).

British Engineering Standards Association.
(*Incorporated 1918.*)
FORMED IN 1901 AS THE ENGINEERING STANDARDS COMMITTEE
BY
THE INSTITUTION OF CIVIL ENGINEERS.
THE INSTITUTION OF MECHANICAL ENGINEERS.
THE INSTITUTION OF NAVAL ARCHITECTS.
THE IRON AND STEEL INSTITUTE.
THE INSTITUTION OF ELECTRICAL ENGINEERS.

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BRITISH STANDARD SPECIFICATIONS FOR RAILWAY ROLLING STOCK MATERIAL.

PART VI.

STEEL PLATES, ANGLES, ETC., AND RIVETS FOR LOCOMOTIVES, CARRIAGES AND WAGONS.

(REVISED DECEMBER, 1911.)

LONDON:
PUBLISHED FOR THE ASSOCIATION BY CROSBY LOCKWOOD & SON,
7, STATIONERS' HALL COURT, LUDGATE HILL, E.C. 4; AND 5, BROADWAY, LONDON, S.W. 1;
AND TO BE PURCHASED FROM ANY BOOKSELLER, OR DIRECT FROM THE OFFICES OF THE ASSOCIATION,
28, VICTORIA STREET, LONDON, S.W. 1.

November, 1918.

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PRICE 1/- Net.

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PART V. Copper Plates, Rods and Tubes, and Brass Tubes.

BRITISH ENGINEERING STANDARDS ASSOCIATION.

MAIN COMMITTEE.

†SIR ARCHIBALD DENNY, BART. (*Chairman*).
SIR MAURICE FITZMAURICE, C.M.G. (*Vice-Chairman*).

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SIR ROBERT HADFIELD, BART.	
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DR. J. H. T. TUDSBERY (*Hon. Secretary*).

MR. C. LE MAISTRE (*Secretary*).
MR. CHARLES DRESSER (*Assistant Secretary*).

† Succeeded the late SIR JOHN WOLFE BARRY, K.C.B., February, 1918.

BRITISH ENGINEERING STANDARDS ASSOCIATION.

The following are lists of the Members of the Sectional Committee on Locomotives and its Sub-Committees, and of the Sectional Committee on Railway Rolling Stock Underframes.

SECTIONAL COMMITTEE ON LOCOMOTIVES.

December, 1911.

Chairman, SIR DOUGLAS FOX.

War Office, *Major A. G. Stevenson, D.S.O., R.E.

India Office, Mr. A. Brereton, C.S.I.

Crown Agents for the Colonies: Mr. G. L. Eyles, C.M.G.; Mr. Ashton M. Heath.

Locomotive Manufacturers' Parliamentary Association: Mr. W. Lorimer (*North British Locomotive Co., Ltd.*); †Mr. Hugh Reid (*North British Locomotive Co., Ltd.*); **Mr. T. P. Reay (*Kitson & Co., Ltd.*).

Railway Companies' Association: Mr. J. A. F. Aspinall (*Lancashire and Yorkshire Railway*); Mr. J. F. McIntosh, M.V.O. (*Caledonian Railway*).

Association of Railway Locomotive Engineers: Mr. G. J. Churchward (*Great Western Railway*); ‡Mr. G. H. Hughes (*Lancashire and Yorkshire Railway*).

Steel Ingot Makers' Association: §Mr. Maxmilian Mannaberg (*Frodingham Iron and Steel Co., Ltd.*).

Steel Founders' Association of Great Britain: Sir Robert Hadfield (*Hadfield's Steel Foundry Co., Ltd.*)

Mr. F. Wolley-Dod (*Chairman of the Calcutta Conference, 1901*).

**Sir John Wolfe Barry, K.C.B.; Mr. G. Ainsworth (*Consett Iron Co., Ltd.*); **Mr. H. C. Arbuthnott (*Taylor Bros. & Co., Ltd.*); Mr. J. Hartley Bibby (*John Bibby, Sons & Co.*); Mr. D. Cassels (*Steel Company of Scotland, Ltd.*); Mr. W. Collingwood (*Vulcan Foundry, Ltd.*); Mr. J. M. Dobson (*Hawkshaw & Dobson*); ||Mr. J. Duncan Elliot (*Carruthers & Elliot*); Mr. F. C. Fairholme (*Thomas Firth & Sons, Ltd.*); Mr. C. N. Goodall (*Robert Stephenson & Co., Ltd.*); Mr. E. Greg, Jnr. (*Nasmyth, Wilson & Co., Ltd.*); Mr. Cyril Hitchcock (*Sir George Bruce & White*); ¶Mr. A. F. Halstead (*Beyer, Peacock & Co., Ltd.*); Mr. Bradford Leslie (*A. J. Barry & Leslie*); Mr. Edward Mills (*Williams, Foster & Co.*, and *Pascoe, Grenfell & Sons, Ltd.*); **Mr. F. E. Robertson, C.I.E. (*Rendel & Robertson*); Mr. Frederick Tomlinson (*Broughton Copper Co., Ltd.*); Mr. Seymour B. Tritton (*Rendel & Robertson*); Mr. J. N. Vickers (*Vickers, Ltd.*); Mr. Robert White (*Sir George Bruce & White*).

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* Succeeded Major T. H. Cochrane, M.V.O., R.E., October, 1909.

† Succeeded Mr. J. F. Robinson, January, 1910.

‡ Succeeded Mr. James Holden, June, 1908.

§ Succeeded Mr. F. W. Dick, July, 1909.

|| Succeeded Mr. John Carruthers, July, 1910.

¶ Succeeded Mr. A. S. Jameson, June, 1911.

** Deceased.

SECTIONAL COMMITTEE ON RAILWAY ROLLING STOCK UNDERFRAMES.

December, 1911.

Chairman, SIR DOUGLAS FOX.

Crown Agents for the Colonies : Mr. G. L. Eyles, C.M.G. ; Mr. Ashton M. Heath.

Mr. D. Bain (*Midland Railway*) ; Mr. Lincoln Chandler (*Metropolitan Amalgamated Railway Carriage and Wagon Co., Ltd.*) ; Mr. Thomas G. Clayton (*late Midland Railway*) ; Mr. Brodie Henderson (*Livesey, Son & Henderson*) ; †Mr. G. A. Hobson (*Sir Douglas Fox & Partners*) ; *Mr. H. D Earl (*London & North Western Railway*) ; †Mr. F. E. Robertson, C.I.E. (*Rendel & Robertson*) ; Mr. H. J. Skelton (*H. J. Skelton & Co.*).

* Succeeded Mr. C. A. Park, June, 1910.

† Deceased.

LOCOMOTIVE SUB-COMMITTEES.

December, 1911.

SUB-COMMITTEE ON TYRES, AXLES AND SPRINGS.

Chairman, Mr. G. J. Churchward.

†Mr. H. C. Arbuthnott ; Mr. W. J. Armitage ; Mr. D. Bain ; Mr. Lincoln Chandler ; Mr. F. C. Fairholme ; Mr. Albert Good ; Mr. Richard Halstead ; Mr. Ashton M. Heath ; Mr. C. Hitchcock ; Mr. Henry Steel, Jnr. ; Dr. W. C. Unwin.

SUB-COMMITTEE ON LOCOMOTIVE STEEL PLATES.

Chairman, Mr. W. Lorimer.

Mr. G. Ainsworth ; Mr. D. Cassels ; Mr. Maxmilian Mannaberg ; †Mr. T. P. Reay ; Dr. W. C. Unwin.

SUB-COMMITTEE ON COPPER AND ITS ALLOYS.

Chairman, Mr. J. F. McIntosh, M.V.O.

Mr. J. Hartley Bibby ; Mr. Edward Mills ; Mr. Hugh Reid ; Mr. Frederick Tomlinson.

† Deceased.

PREFACE TO FIRST EDITION.

The subject of the Standardisation of Locomotives was first raised at a meeting of the Main Committee on January 14th, 1902, when Sir John Wolfe Barry recorded interviews he had had with Lord George Hamilton and other officials of the India Office with regard to this subject, and it was agreed that evidence should be collected. On March 4th, 1902, the Main Committee sat to hear evidence on the subject, and this being in favour of proceeding, a Sectional Committee on Locomotives was formed under the Chairmanship of Sir Douglas Fox.

The Sectional Committee on Locomotives held their first meeting on May 30th, 1902, when the following Sub-Committees were formed :—

Name.	*Chairman.*
Locomotive Steel Plates . .	Mr. W. LORIMER.
Tyres, Axles and Springs . .	Mr. W. LORIMER.
Copper and its Alloys . .	Mr. W. DEAN.
	(Succeeded by Mr. J. F. McINTOSH.)

A number of meetings of the Sub-Committees have been held, and the report in its present form was adopted by the Sectional Committee on Locomotives at their meeting held on March 23rd, 1906.

The Sectional Committee on Locomotives desire to place on record their appreciation of the services rendered by the Association of Railway Locomotive Engineers through their representatives on the Committee.

In many instances somewhat divergent opinions have had to be reconciled, and this has only been rendered possible by accepting the view that the Standard Specifications will be considered from time to time as occasion requires, and the Sectional Committee are desirous of making this point clear when submitting their Report.

To meet the various needs of the Home, Indian and Colonial requirements, the Committee have in many cases included similar Specifications—one with, and the other without, a Chemical Analysis —in order that those who do not desire to specify a Chemical Analysis can still use a Standard Specification.

The Sectional Committee on Railway Rolling Stock Underframes, under the same Chairman, was appointed by the Main Committee at their meeting on July 16th, 1901. Having, in conjunction with the Sectional Committee on Sections used in Shipbuilding and that on Bridges and General Building Construction, completed the drawing up of a list of Standard Sections, the preparation of a Standard Specification was proceeded with. For convenience of publishing, this Specification is included in the present volume, and constitutes Specification No. 17.

The Specifications were considered by the Sectional Committee on Underframes at a meeting held in conjunction with the Sectional Committee on Locomotives on March 23rd, 1906, and finally adopted by the Sectional Committee on Locomotives at their meeting held on July 12th, 1906.

The Reports of the two Sectional Committees, which are contained in the present volume, were approved by the Main Committee at the meeting held on July 26th, 1906.

DOUGLAS FOX,

Chairman of the Sectional Committees on Locomotives and Railway Rolling Stock Underframes.

PREFACE TO SECOND EDITION.

Since the issue of the first revision in June, 1907, the Committees on Locomotives and Railway Rolling Stock Underframes have from time to time had brought before them points which have arisen in connection with the use of the Standard Specifications, and the present issue of Report No. 24 embodies the Committee's decisions in regard to these. Some of the more important modifications to the Specifications are as follows :—

1. The prohibition of a re-test in the case of failure under the falling weight test for Axles.

2. The option of a bend test in the Specification for Carriage and Wagon Axles (without analysis) if there is any question in the mind of the Engineer as to the Axle having satisfactorily passed the falling weight test.

3. The deletion of the Specification (without analysis) for Locomotive Tyres.

4. The deletion of Class **B** tyres (42-48 tons per square inch) from the Specification (with analysis) for Locomotive Tyres.

5. The addition of Class **C** tyres (50-55 tons per square inch) to the Specification (without analysis) for Carriage and Wagon Tyres.

6. The deletion of Class **A** tyres (35-40 tons per square inch) from the Specification (without analysis) for Carriage and Wagon Tyres.

7. The insertion in the Tyre Specifications of a formula for the deflection under the falling weight test based upon the thickness and internal diameter of the tyre in place of that previously employed, which was based upon the internal diameter only.

8. The division of the Specifications for Laminated Springs and Spring Steel into separate Specifications, dealing respectively with Spring Steel and with the finished Springs.

   With a view of restricting the tensile stress on the plates of the finished Spring under the scragging test to a figure somewhat below 70 tons per square inch, a definite deflection, depending upon the length of the top plate of the Spring and thickness of the thickest plate, is now specified, and a table of the required deflections is inserted in the Specification.

9. The addition of a further class of Forgings (Class **E**) to the Forging Specification.

10. The reduction of the tensile strength of Rivet Bars to 24-28 tons per square inch.

The Committee have had representations made to them with regard to the use of the term "*Elastic Limit*" in the Axle and Forging Specifications, and this term has now been altered to "*Yield Point*," a definition of this latter term being added as a note to the Specifications in which this term is employed.

The Committee recommend that in specifying materials to any of the Specifications contained in this Report, both the Specification number and the number of the Report be quoted, in order to obviate confusion with other Reports of the Committee.

The Report in its present form was approved by the Sectional Committees concerned in October, 1911, and by the Main Committee on December 6th, 1911.

DOUGLAS FOX,

Chairman of the Sectional Committee on Locomotives and Railway Rolling Stock Underframes.

Reference to be quoted.

Report No. 24
Specification No. 16-1911

Note.—The Association desires to call attention to the fact that this Specification is intended to include the technical provisions necessary for the supply of the material herein referred to, but does not purport to include all the necessary provisions of a Contract.

BRITISH STANDARD SPECIFICATION FOR STEEL FOR PLATES, ANGLES, ETC., AND RIVETS FOR LOCOMOTIVE BOILERS.

(REVISED DECEMBER, 1911.)

Quality of Material.

1. The Plates, Sections and Bars shall be manufactured from Steel made from selected material by the Acid Open Hearth process and must not show on analysis more than 0·05 per cent. of Sulphur or of Phosphorus.

The Manufacturer shall supply an analysis when required to do so.

Freedom from Defects.

2. The Plates, Sections and Bars must be free from cracks, surface flaws, lamination, and all other defects, and finished in a workmanlike manner.

Rolling Margin.

3. No Plate must be under the specified thickness at any part, nor more than 5 per cent. over the calculated weight.

Branding.

4. Each Plate, Section or Bar, shall be distinctly stamped with such brands as the Engineer (or the Purchaser) may require, but not near the edge.

Mechanical Tests.

5. The tensile strength and ductility shall be determined from Standard test pieces cut crosswise from the rolled material in the case of Plates, and lengthwise in the case of Sectional Material. When material is annealed or otherwise treated before dispatch, the test pieces shall be similarly and simultaneously treated with the material before testing.

Any straightening of test pieces which may be required shall be done cold.

Reference to be quoted,

Report No. 24
Specification No. 16-1911

Tensile Tests.

6. Plates and Sectional Material:—For Plates, Angles, etc., a Standard Test Piece **A,** having a gauge length of 8 inches (*see* Appendix, page 34), and for Round Bars (other than Rivet Bars) a Standard Test Piece **B,** having a gauge length of not less than 8 times the diameter (*see* Appendix, page 35), must show a tensile breaking strength of 26 to 32 tons per square inch, with an elongation of not less than 22 per cent. Where bars are above 1 inch in diameter and are tested full size as rolled, or have been turned down and the resulting test piece is above 1 inch in diameter, a Standard Test Piece **F,** having a gauge length of not less than 4 times the diameter (*see* Appendix, page 36) may be used, in which case the elongation shall be not less than 27 per cent.

Rivet Bars:—A Standard Test Piece **B,** having a gauge length of not less than 8 times the diameter (*see* Appendix, page 35), must show a tensile breaking strength of 24 to 28 tons per square inch, with an elongation of not less than 27 per cent. If tested on a Standard Test Piece **F,** having a gauge length of not less than 4 times the diameter (*see* Appendix, page 36), the elongation shall be not less than 32 per cent. The Bars may be tested the full size as rolled.

Number of Tensile Tests.

7. One tensile test shall be taken from each end of each Plate as rolled, and at least two tensile tests for Angle and Rivet Bars shall be taken from each cast.

Should a tensile test piece break outside the middle half of its gauge length, the test may, at the Manufacturer's option, be discarded, and another test be made of the same Plate or Bar.

Bend Tests.

8. Cold Bends:—Test pieces shall be sheared crosswise from Plates and lengthwise from Angles or Bars, and shall be not less than $1\frac{1}{2}$ inches wide, but for small Angles or Bars the whole section may be used.

Temper Bends:—The test pieces shall be similar to those used for cold bend tests. For temper bend tests the test pieces shall be heated to a blood red and quenched in water at a temperature not exceeding 80° Fahr. The colour shall be judged indoors in the shade.

In all cold or temper bend tests the sheared edges may be removed by filing, planing, grinding, or other method. The test

pieces shall not be annealed, unless the material from which they are cut is similarly annealed, in which case the test pieces shall be similarly and simultaneously treated with the material before testing.

For both cold and temper bends the test piece must withstand, without fracture, being doubled over until the internal radius is not greater than the thickness of the test piece, and the sides are parallel.

Bend tests may be made either by pressure or by blows.

For Rivet Bars, temper bend tests only are required.

Number of Bend Tests.

9. One cold or one temper bend test shall be taken from each Plate, Section or Bar as rolled.

Tests for Manufactured Rivets.

10. Rivets selected by the representative of the Engineer (or of the Purchaser) from the bulk, in such proportion as may be specified and approved, must withstand the following tests :—

(*a*) The Rivet shanks shall be bent cold, and hammered until the two parts of the shank touch in the manner shown in Fig. 1, without fracture on the outside of the bend.

(*b*) The Rivet heads shall be flattened, while hot, in the manner shown in Fig. 2, without cracking at the edges. The head shall be flattened until its diameter is $2\frac{1}{2}$ times the diameter of the shank.

Fig. 1.

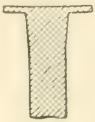


Fig. 2.

Facilities for Inspection.

11. The Maker shall adopt a system of marking the Ingots, Billets, Slabs, Plates, Sectional Material, etc., which will enable all finished material to be traced to the original cast; and the representative of the Engineer (or of the Purchaser) shall be given every facility for tracing all Plates and Sectional Material to their respective cast, and for witnessing the required tests.

Inspection.

12. The representative of the Engineer (or of the Purchaser) shall have free access to the works of the Manufacturer at all reasonable times; he shall be at liberty to inspect the manufacture at any stage, and to reject any material that does not conform to the terms of this Specification.

Testing Facilities.

13. The Manufacturer shall supply the material required for testing free of charge and shall, at his own cost, furnish and prepare the necessary test pieces, and supply labour and appliances for such testing as may be carried out on his premises in accordance with this Specification. Failing facilities at his own works for making the prescribed tests, the Manufacturer shall bear the cost of carrying out the tests elsewhere.

Reference to be quoted.

Report No. 24
Specification No. 17-1911

Note.—*The Association desires to call attention to the fact that this Specification is intended to include the technical provisions necessary for the supply of the material herein referred to, but does not purport to include all the necessary provisions of a Contract.*

BRITISH STANDARD SPECIFICATION FOR STEEL FOR PLATES, ANGLES, ETC., AND RIVETS FOR LOCOMOTIVES.

(WITH ANALYSIS.)

[THIS SPECIFICATION DOES NOT APPLY TO BOILERS.]

(REVISED DECEMBER, 1911.)

Quality of Material.

1. The Plates, Sections and Bars shall be manufactured from Steel made from selected material by the Acid or Basic Open Hearth process, and must not show on analysis more than 0·06 per cent. of Sulphur or of Phosphorus.

The Manufacturer shall supply an analysis when required to do so.

Freedom from Defects.

2. The Plates, Sections and Bars must be free from cracks, surface flaws, lamination, and all other defects, and finished in a workmanlike manner.

Rolling Margin.

3. No Plate, Section or Bar must be more than $2\frac{1}{2}$ per cent. over or $2\frac{1}{2}$ per cent. under the calculated weight.

Branding.

4. Each Plate, Section or Bar shall be distinctly stamped with such Brands as the Engineer (or the Purchaser) may require, but not near the edge.

Mechanical Tests.

5. The tensile strength and ductility shall be determined from Standard test pieces cut lengthwise or crosswise from the rolled

material in the case of Plates, and lengthwise in the case of Sectional Material. When material is annealed or otherwise treated before despatch, the test pieces shall be similarly and simultaneously treated with the material before testing.

Any straightening of test pieces which may be required shall be done cold.

Tensile Tests.

6. Plates:—A Standard Test Piece **A,** having a gauge length of 8 inches (*see* Appendix, page 34) must show a tensile breaking strength of 28 to 32 tons per square inch with an elongation of not less than 20 per cent. for Plates of 0·375 inch in thickness and upwards, and 16 per cent. for Plates below 0·375 inch in thickness

Sectional Material:—For Angles, etc., a Standard Test Piece **A,** having a gauge length of 8 inches (*see* Appendix, page 34), and for Round Bars (other than Rivet Bars) a Standard Test Piece **B,** having a gauge length of not less than 8 times the diameter (*see* Appendix, page 35), must show a tensile breaking strength of 28 to 32 tons per square inch with an elongation of not less than 20 per cent. Where bars are above 1 inch in diameter and are tested full size as rolled, or have been turned down and the resulting test piece is above 1 inch in diameter, a Standard Test Piece **F,** having a gauge length of not less than 4 times the diameter (*see* Appendix, page 36), may be used, in which case the elongation shall be not less than 24 per cent. For material under $\frac{5}{16}$ inch (0·312 inch) in thickness bend tests only are required.

Rivet Bars:—A Standard Test Piece **B,** having a gauge length of not less than 8 times the diameter (*see* Appendix, page 35), must show a tensile breaking strength of 24 to 28 tons per square inch, with an elongation of not less than 27 per cent. If tested on a Standard Test Piece **F,** having a gauge length of not less than 4 times the diameter (*see* Appendix, page 36), the elongation shall be not less than 32 per cent. The Bars may be tested the full size as rolled.

Number of Tensile Tests.

7. At least two tensile tests shall be taken from every cast whether for Plates, Sections or Bars.

Should a tensile test piece break outside the middle half of its gauge length the test may, at the Manufacturer's option, be discarded, and another test be made of the same Plate, Section or Bar.

Bend Tests.

8. Cold Bends :—Test pieces shall be sheared lengthwise or crosswise from Plates and lengthwise from Sections or Bars, and shall be not less than $1\frac{1}{2}$ inches wide, but for small Sections or Bars the whole section may be used.

Temper Bends :—The test pieces shall be similar to those used for cold bend tests. For temper bend tests the test pieces shall be heated to a blood red and quenched in water at a temperature not exceeding 80° Fahr. The colour shall be judged indoors in the shade.

In all cold or temper bend tests the sheared edges may be removed by milling, planing, grinding, or other method. The test pieces shall not be annealed unless the material from which they are cut is similarly annealed, in which case the test pieces shall be similarly and simultaneously treated with the material before testing.

For both cold and temper bends the test piece must withstand, without fracture, being doubled over until the internal radius is not greater than $1\frac{1}{2}$ times the thickness of the test piece, and the sides are parallel.

For small sectional material these bend tests may be made from the flattened bar.

Bend tests may be made by pressure or by blows.

For Rivet Bars, temper bend tests only are required.

Number of Bend Tests.

9. One cold or one temper bend test shall be taken from each Plate, Section or Bar as rolled.

Tests for Manufactured Rivets.

10. Rivets selected by the representative of the Engineer (or of the Purchaser) from the bulk, in such proportion as may be specified and approved, must withstand the following tests :—

(*a*) The Rivet shanks shall be bent cold, and hammered until the two parts of the shank touch in the manner shown in Fig. 1, without fracture on the outside of the bend.

(*b*) The Rivet heads shall be flattened, while hot, in the manner shown in Fig. 2, without cracking at the edges. The head shall be flattened until its diameter is $2\frac{1}{2}$ times the diameter of the shank.

Fig. 1.

Fig. 2

Reference to be quoted.
Report No. 24
Specification No. 17-1911

Facilities for Inspection.

11. The Maker shall adopt a system of marking the Ingots, Billets, Slabs, Plates, Sectional Material, etc., which will enable all finished material to be traced to the original cast ; and the representative of the Engineer (or of the Purchaser) shall be given every facility for tracing all Plates and Sectional Material to their respective cast, and for witnessing the required tests.

Inspection.

12. The representative of the Engineer (or of the Purchaser) shall have free access to the works of the Manufacturer at all reasonable times ; he shall be at liberty to inspect the manufacture at any stage, and to reject any material that does not conform to the terms of this Specification.

Testing Facilities.

13. The Manufacturer shall supply the material required for testing free of charge and shall, at his own cost, furnish and prepare the necessary test pieces, and supply labour and appliances for such testing as may be carried out on his premises in accordance with this Specification. Failing facilities at his own works for making the prescribed tests, the Manufacturer shall bear the cost of carrying out the tests elsewhere.

Reference to be quoted.

Report No. 24
Specification No. 17a-1911

Note.—*The Association desires to call attention to the fact that this Specification is intended to include the technical provisions necessary for the supply of the material herein referred to, but does not purport to include all the necessary provisions of a Contract.*

BRITISH STANDARD SPECIFICATION FOR STEEL FOR PLATES, ANGLES, ETC., AND RIVETS FOR LOCOMOTIVES.

(WITHOUT ANALYSIS.)

[THIS SPECIFICATION DOES NOT APPLY TO BOILERS.]

(REVISED DECEMBER, 1911.)

Quality of Material.

1. The Plates, Sections and Bars shall be manufactured from Steel made by the Acid or Basic Open Hearth process.

Freedom from Defects.

2. The Plates, Sections and Bars must be free from cracks, surface flaws, laminations, and all other defects, and finished in a workmanlike manner.

Rolling Margin.

3. No Plate, Section or Bar must be more than $2\frac{1}{2}$ per cent. over or $2\frac{1}{2}$ per cent. under the calculated weight.

Branding.

4. Each Plate, Section or Bar shall be distinctly stamped with such Brands as the Engineer (or the Purchaser) may require, but not near the edge.

Mechanical Tests.

5. The tensile strength and ductility shall be determined from Standard test pieces cut lengthwise or crosswise from the rolled material in the case of Plates, and lengthwise in the case of Sectional Material. When material is annealed or otherwise treated before despatch, the test pieces shall be similarly and simultaneously treated with the material before testing.

Any straightening of test pieces which may be required shall be done cold.

Tensile Tests.

6. Plates :—A Standard Test Piece **A,** having a gauge length of 8 inches (*see* Appendix, page 34), must show a tensile breaking strength of 28 to 32 tons per square inch with an elongation of not less than 20 per cent. for Plates of 0·375 inch in thickness and upwards, and 16 per cent. for Plates below 0·375 inch in thickness.

Sectional Material :—For Angles, etc., a Standard Test Piece **A,** having a gauge length of 8 inches (*see* Appendix, page 34), and for Round Bars (other than Rivet Bars) a Standard Test Piece **B,** having a gauge length of not less than 8 times the diameter (*see* Appendix, page 35) must show a tensile breaking strength of 28 to 32 tons per square inch with an elongation of not less than 20 per cent. Where bars are above 1 inch in diameter and are tested full size as rolled, or have been turned down and the resulting test piece is above 1 inch in diameter, a Standard Test Piece **F,** having a gauge length of not less than 4 times the diameter (*see* Appendix, page 36), may be used, in which case the elongation shall be not less than 24 per cent. For material under $\frac{5}{16}$ inch (0·312 inch) in thickness bend tests only are required.

Rivet Bars :—A Standard Test Piece **B,** having a gauge length of not less than 8 times the diameter (*see* Appendix, page 35), must show a tensile breaking strength of 24 to 28 tons per square inch, with an elongation of not less than 27 per cent. If tested on a Standard Test Piece **F,** having a gauge length of not less than 4 times the diameter (*see* Appendix, page 36), the elongation shall be not less than 32 per cent. The Bars may be tested the full size as rolled.

Number of Tensile Tests.

7. At least two tensile tests shall be taken from every cast, whether for Plates, Sections or Bars.

Should a tensile test piece break outside the middle half of its gauge length the test may, at the Manufacturer's option, be discarded, and another test be made of the same Plate, Section or Bar.

Bend Tests.

8. Cold Bends :—Test pieces shall be sheared lengthwise or crosswise from Plates and lengthwise from Sections or Bars, and shall be not less than 1½ inches wide, but for small Sections or Bars the whole section may be used.

Temper Bends :—The test pieces shall be similar to those used for cold bend tests. For temper bend tests the test pieces shall be heated to a blood red and quenched in water at a temperature not exceeding 80° Fahr. The colour shall be judged indoors in the shade.

In all cold or temper bend tests the sheared edges may be removed by milling, planing, grinding, or other method. The test pieces shall not be annealed unless the material from which they are cut is similarly annealed, in which case the test pieces shall be similarly and simultaneously treated with the material before testing.

For both cold and temper bends the test piece must withstand, without fracture, being doubled over until the internal radius is not greater than 1½ times the thickness of the test piece, and the sides are parallel.

For small sectional material these bend tests may be made from the flattened bar.

Bend tests may be made by pressure or by blows.

For Rivet Bars, temper bend tests only are required.

Number of Bend Tests.

9. One cold or one temper bend test shall be taken from each Plate, Section or Bar as rolled.

Tests for Manufactured Rivets.

10. Rivets selected by the representative of the Engineer (or of the Purchaser) from the bulk, in such proportion as may be specified and approved, must withstand the following tests :—

(*a*) The Rivet shanks shall be bent cold, and hammered until the two parts of the shank touch in the manner shown in Fig. 1, without fracture on the outside of the bend.

(*b*) The Rivet heads shall be flattened, while hot, in the manner shown in Fig. 2, without cracking at the edges. The head shall be flattened until its diameter is 2½ times the diameter of the shank.

Fig. 1.

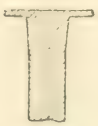


Fig. 2.

Facilities for Inspection.

11. The Maker shall adopt a system of marking the Ingots, Billets, Slabs, Plates, Sectional Material, etc., which will enable all

finished material to be traced to the original cast; and the representative of the Engineer (or of the Purchaser) shall be given every facility for tracing all Plates and Sectional Material to their respective cast, and for witnessing the required tests.

Inspection.

12. The representative of the Engineer (or of the Purchaser) shall have free access to the works of the Manufacturer at all reasonable times; he shall be at liberty to inspect the manufacture at any stage, and to reject any material that does not conform to the terms of this Specification.

Testing Facilities.

13. The Manufacturer shall supply the material required for testing free of charge and shall, at his own cost, furnish and prepare the necessary test pieces, and supply labour and appliances for such testing as may be carried out on his premises in accordance with this Specification. Failing facilities at his own works for making the prescribed tests, the Manufacturer shall bear the cost of carrying out the tests elsewhere.

Reference to be quoted.

Report No. 24
Specification No. 18-1911

Note.—*The Association desires to call attention to the fact that this Specification is intended to include the technical provisions necessary for the supply of the material herein referred to, but does not purport to include all the necessary provisions of a Contract.*

BRITISH STANDARD SPECIFICATION FOR STEEL FOR PLATES, ANGLES, ETC., AND RIVETS FOR CARRIAGES AND WAGONS.

(WITH ANALYSIS.)

(REVISED DECEMBER, 1911.)

Quality of Material.

1. The Plates, Sections and Bars shall be manufactured from Steel made from selected material by the Acid or Basic Open Hearth process, and must not show on analysis more than 0·06 per cent. of Sulphur or of Phosphorus.

The Manufacturer shall supply an analysis when required to do so.

Freedom from Defects.

2. The Plates, Sections and Bars must be free from cracks, surface flaws, laminations, and all other defects, and finished in a workmanlike manner.

Rolling Margin.

3. No Plate, Section or Bar must be more than $2\frac{1}{2}$ per cent. over or $2\frac{1}{2}$ per cent. under the calculated weight.

Branding.

4. Each Plate, Section or Bar shall be distinctly stamped with such brands as the Engineer (or the Purchaser) may require, but not near the edge.

Mechanical Tests.

5. The tensile strength and ductility shall be determined from Standard test pieces cut lengthwise or crosswise from the rolled material in the case of Plates, and lengthwise in the case of Sectional Material. When material is annealed or otherwise treated before despatch the test pieces shall be similarly and simultaneously treated with the material before testing.

Any straightening of test pieces which may be required shall be done cold.

Tensile Tests.

6. Plates and Sectional Material:—For Plates, Angles, etc., a Standard Test Piece **A,** having a gauge length of 8 inches (*see* Appendix, page 34), and for Round Bars (other than Rivet Bars) a Standard Test Piece **B,** having a gauge length of not less than 8 times the diameter (*see* Appendix, page 35), must show a tensile breaking strength of 28 to 32 tons per square inch, with an elongation of not less than 20 per cent. Where bars are above 1 inch in diameter and are tested full size as rolled or are turned down and the resulting test piece is above 1 inch in diameter, a Standard Test Piece **F,** having a gauge length of not less than 4 times the diameter (*see* Appendix, page 36), may be used, in which case the elongation shall be not less than 24 per cent. For material under $\frac{5}{16}$ inch (0·312 inch) in thickness bend tests only are required.

Rivet Bars, and such material as may be required for smithing and stamping purposes:—A Standard Test Piece **B,** having a gauge length of not less than 8 times the diameter, or a Standard Test Piece **A,** having a gauge length of 8 inches, as may be most suitable for the purpose required (*see* Appendix, pages 34 and 35), must show a tensile breaking strength of 24 to 28 tons per square inch, with an elongation of not less than 27 per cent. If tested on a Standard Test Piece **F,** having a gauge length of not less than 4 times the diameter (*see* Appendix, page 36), the elongation shall be not less than 32 per cent. The Bars may be tested the full size as rolled.

Number of Tensile Tests.

7. One tensile test shall be taken from every cast or every 25 tons whichever is least.

Should a tensile test piece break outside the middle half of its gauge length the test may, at the Manufacturer's option, be discarded, and another test be made of the same Plate, Section or Bar.

Bend Tests.

8. Cold bends:—Test pieces shall be sheared or cut lengthwise or crosswise from Plates and lengthwise from Sections or Bars, and shall be not less than $1\frac{1}{2}$ inches wide, but for small Sections or Bars the whole section may be used.

Temper Bends:—The test pieces shall be similar to those used for cold bend tests. For temper bend tests the test pieces shall be heated to a blood red and quenched in water at a temperature not exceeding 80° Fahr. The colour shall be judged indoors in the shade.

In all cold or temper bend tests, the sheared edges may be removed by milling, planing, grinding, or other method. The test pieces shall not be annealed unless the material from which they are cut is similarly annealed, in which case the test pieces shall be similarly and simultaneously treated with the material before testing.

For both cold and temper bends the test piece must withstand, without fracture, being doubled over until the internal radius is not greater than $1\frac{1}{2}$ times the thickness of the test piece and the sides are parallel.

For small sectional material these bend tests may be made from the flattened bar.

Bend tests may be made by pressure or by blows.

For Rivet Bars, temper bend tests only are required.

Number of Bend Tests

9. Two per cent. of cold and two per cent. of temper bend tests shall be taken from the number of Plates, Sections, or Bars ordered under the contract.

Tests for Manufactured Rivets.

10. Rivets selected by the representative of the Engineer (or of the Purchaser) from the bulk, in such proportion as may be specified and approved, must withstand the following tests:—

(*a*) The Rivet shanks shall be bent cold, and hammered until the two parts of the shank touch in the manner shown in Fig. 1, without fracture on the outside of the bend.

(*b*) The Rivet heads shall be flattened, while hot, in the manner shown in Fig. 2, without cracking at the edges. The head shall be flattened until its diameter is $2\frac{1}{2}$ times the diameter of the shank.

Fig. 1.

Fig. 2.

Facilities for Inspection.

11. The Maker shall adopt a system of marking the Ingots, Billets, Slabs, Plates, Sectional Material, etc., which will enable all finished material to be traced to the original cast; and the representative of the Engineer (or of the Purchaser) shall be given every facility for tracing all Plates and Sectional Material to their respective cast, and for witnessing the required tests.

Inspection.

12. The representative of the Engineer (or of the Purchaser) shall have free access to the works of the Manufacturer at all reasonable times; he shall be at liberty to inspect the manufacture at any stage, and to reject any material that does not conform to the terms of this Specification.

Testing Facilities.

13. The Manufacturer shall supply the material required for testing free of charge and shall, at his own cost, furnish and prepare the necessary test pieces, and supply labour and appliances for such testing as may be carried out on his premises in accordance with this Specification. Failing facilities at his own works for making the prescribed tests, the Manufacturer shall bear the cost of carrying out the tests elsewhere.

Reference to be quoted.

Report No. 24

Specification No. 18a-1911

Note.—*The Association desires to call attention to the fact that this Specification is intended to include the technical provisions necessary for the supply of the material herein referred to, but does not purport to include all the necessary provisions of a Contract.*

BRITISH STANDARD SPECIFICATION FOR STEEL FOR PLATES, ANGLES, ETC., AND RIVETS FOR CARRIAGES AND WAGONS.

(WITHOUT ANALYSIS.)

(REVISED DECEMBER, 1911).

Quality of Material.

1. The Plates, Sections and Bars shall be manufactured from Steel made from selected materials by the Acid or Basic Open Hearth process.

Freedom from Defects.

2. The Plates, Sections and Bars must be free from cracks, surface flaws, laminations, and all other defects, and finished in a workmanlike manner.

Rolling Margin.

3. No Plate, Section or Bar must be more than $2\frac{1}{2}$ per cent. over or $2\frac{1}{2}$ per cent. under the calculated weight.

Branding.

4. Each Plate, Section or Bar shall be distinctly stamped with such brands as the Engineer (or the Purchaser) may require, but not near the edge.

Mechanical Tests.

5. The tensile strength and ductility shall be determined from Standard Test pieces cut lengthwise or crosswise from the rolled material in the case of Plates, and lengthwise in the case of Sectional Material. When material is annealed or otherwise treated before despatch the test pieces shall be similarly and simultaneously treated with the material before testing.

Any straightening of test pieces which may be required shall be done cold.

Tensile Tests.

6. Plates and Sectional Material:—For Plates, Angles, etc., a Standard Test Piece **A,** having a gauge length of 8 inches (*see* Appendix, page 34), and for Round Bars (other than Rivet Bars) a Standard Test Piece **B,** having a gauge length of not less than 8 times the diameter (*see* Appendix, page 35), must show a tensile breaking strength of 28 to 32 tons per square inch, with an elongation of not less than 20 per cent. Where bars are above 1 inch in diameter and are tested full size as rolled or are turned down and the resulting test piece is above 1 inch in diameter, a Standard Test Piece **F,** having a gauge length of not less than 4 times the diameter (*see* Appendix, page 36), may be used, in which case the elongation shall be not less than 24 per cent. For material under $\frac{5}{16}$ inch (0·312 inch) in thickness bend tests only are required.

Rivet Bars, and such material as may be required for smithing and stamping purposes:—A Standard Test Piece **B,** having a gauge length of not less than 8 times the diameter, or a Standard Test Piece **A,** having a gauge length of 8 inches, as may be most suitable for the purpose required (*see* Appendix, pages 34 and 35), must show a tensile breaking strength of 24 to 28 tons per square inch, with an elongation of not less than 27 per cent. If tested on a Standard Test Piece **F,** having a gauge length of not less than 4 times the diameter (*see* Appendix, page 36), the elongation shall be not less than 32 per cent. The Bars may be tested the full size as rolled.

Number of Tensile Tests.

7. One tensile test shall be taken from every cast or every 25 tons, whichever is least.

Should a tensile test piece break outside the middle half of its gauge length, the test may, at the Manufacturer's option, be discarded, and another test be made of the same Plate, Section or Bar.

Bend Tests.

8. Cold Bends:—Test Pieces shall be sheared or cut lengthwise or crosswise from Plates and lengthwise from Sections or Bars, and shall be not less than $1\frac{1}{2}$ inches wide, but for small Sections or Bars the whole section may be used.

Temper Bends:—The test pieces shall be similar to those used for cold bend tests. For temper bend tests the test pieces shall be heated to a blood red and quenched in water at a temperature not

exceeding 80° Fahr. The colour shall be judged indoors in the shade.

In all cold or temper bend tests, the sheared edges may be removed by milling, planing, grinding, or other method. The test pieces shall not be annealed, unless the material from which they are cut is similarly annealed, in which case the test pieces shall be similarly and simultaneously treated with the material before testing.

For both cold and temper bends the test piece must withstand, without fracture, being doubled over until the internal radius is not greater than $1\frac{1}{2}$ times the thickness of the test piece, and the sides are parallel.

For small sectional material these bend tests may be made from the flattened bar.

Bend tests may be made by pressure or by blows.

For Rivet Bars, temper bend tests only are required.

Number of Bend Tests.

9. Two per cent. of cold and two per cent. of temper bend tests shall be taken from the number of Plates, Sections or Bars ordered under the contract.

Tests for Manufactured Rivets.

10. Rivets selected by the representative of the Engineer (or of the Purchaser) from the bulk, in such proportion as may be specified and approved, must withstand the following tests :—

(*a*) The Rivet shanks shall be bent cold, and hammered until the two parts of the shank touch in the manner shown in Fig. 1, without fracture on the outside of the bend.

(*b*) The Rivet heads shall be flattened, while hot, in the manner shown in Fig. 2, without cracking at the edges. The head shall be flattened until its diameter is $2\frac{1}{2}$ times the diameter of the shank.

Fig. 1.

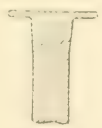


Fig. 2.

Facilities for Inspection.

11. The maker shall adopt a system of marking the Ingots, Billets, Slabs, Plates, Sectional Material, etc., which will enable all

finished material to be traced to the original cast; and the representative of the Engineer (or of the Purchaser) shall be given every facility for tracing all Plates and Sectional Material to their respective cast, and for witnessing the required tests.

Inspection.

12. The representative of the Engineer (or of the Purchaser) shall have free access to the works of the Manufacturer at all reasonable times; he shall be at liberty to inspect the manufacture at any stage, and to reject any material that does not conform to the terms of this Specification.

Testing Facilities.

13. The Manufacturer shall supply the material required for testing free of charge and shall, at his own cost, furnish and prepare the necessary test pieces, and supply labour and appliances for such testing as may be carried out on his premises in accordance with this Specification. Failing facilities at his own works for making the prescribed tests, the Manufacturer shall bear the cost of carrying out the tests elsewhere.

Conversion Table.

Tons.	Pounds.	Tons.	Pounds.
17	38,080	44	98,560
18	40,320	45	100,800
19	42,560	46	103,040
20	44,800	47	105,280
21	47,040	48	107,520
22	49,280	49	109,760
23	51,520	50	112,000
24	53,760	51	114,240
25	56,000	52	116,480
26	58,240	53	118,720
27	60,480	54	120,960
28	62,720	55	123,200
29	64,960	56	125,440
30	67,200	57	127,680
31	69,440	58	129,920
32	71,680	59	132,160
33	73,920	60	134,400
34	76,160	61	136,640
35	78,400	62	138,880
36	80,640	63	141,120
37	82,880	64	143,360
38	85,120	65	145,600
39	87,360	66	147,840
40	89,600	67	150,080
41	91,840	68	152,320
42	94,080	69	154,560
43	96,320	70	156,800

NOTE.—1 Ton = 2,240 lbs.

APPENDIX.

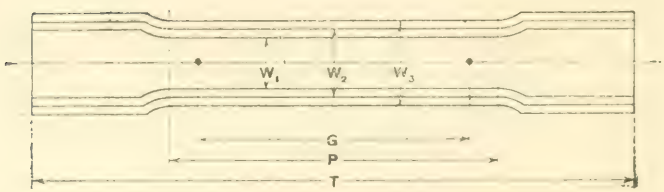
FORMS

OF

BRITISH STANDARD TENSILE TEST PIECES

APPENDIX.

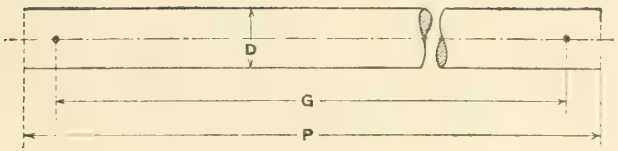
FORMS
OF
BRITISH STANDARD TENSILE TEST PIECES.

TEST PIECE **A.**

Gauge Length **G** = 8 inches.
Parallel Length **P** to be not less than 9 inches.
Total Length **T** = About 18 inches.

Thickness of Test Piece.	Maximum Width allowed.
Over $\frac{7}{8}$ in. (0·875 in.).	$W_1 = 1\frac{1}{2}$ ins.
$\frac{3}{8}$ in. (0·375 in.) to $\frac{7}{8}$ in. (0·875 in.).	$W_2 = 2$ ins.
Under $\frac{3}{8}$ in. (0·375 in.).	$W_3 = 2\frac{1}{2}$ ins.

The widths of the test pieces for plates were selected to comply with the two following conditions. (1) As the great bulk of plates to be tested are from $\frac{3}{8}$ inch to $\frac{7}{8}$ inch thick, it was desirable for the sake of convenience that the test pieces for such plates should be of uniform width, and, in accordance with very general practice, a width of 2 inches was selected. (2) With a test piece of a given form, the percentage of elongation was found to be less for thick plates than for thin ones; with steel of the same quality in other respects it was desirable therefore to choose widths of test piece which would be slightly in favour of the thicker plates. This is secured with the widths selected for the Standard test piece of form **A.**

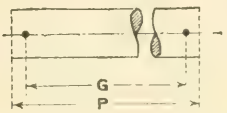
TEST PIECE **B.**



Gauge Length **G** to be not less than 8 times the diameter **D.**
With enlarged ends :—Parallel Length **P** to be not less than 9 times the reduced diameter **D.**

All test pieces of form **B** are strictly similar, and for the same material give the same percentage of elongation. They are nearly similar to a test piece of form **A,** 8 inches in gauge length, 2 inches wide and $\frac{3}{8}$ inch thick.

TEST PIECE **C.**

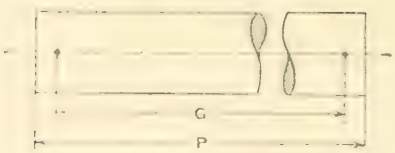


Gauge Length **G** = 2 inches.
Parallel Length **P** to be not less than $2\frac{1}{4}$ inches.
Dia. = 0·564 inch.
Area = $\frac{1}{4}$ sq. inch.

TEST PIECE **D.**

Gauge Length **G** = 3 inches.
Parallel Length **P** to be not less than $3\frac{3}{8}$ inches.
Dia. = 0·798 inch.
Area = $\frac{1}{2}$ sq. inch.

TEST PIECE **E.**

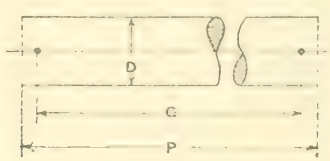


Gauge Length **G** = $3\frac{1}{2}$ inches.
Parallel Length **P** to be not less than 4 inches.
Dia. 0·977 inch.
Area = $\frac{3}{4}$ sq. inch.

Test Pieces **C, D,** and **E** were arranged to meet the very common practice of making test pieces for forgings, axles, tyres, etc., of either $\frac{1}{4}$ square inch or $\frac{1}{2}$ square inch in sectional area. With the gauge lengths decided upon, these three forms are very nearly similar, and, for a given material, give very approximately the same percentage of elongation. Though not exactly, they are approximately similar to the Standard Test Piece **F,** and for the same material give a nearly identical, but slightly greater, percentage of elongation.

TEST PIECE **F.**

(For Test Pieces over 1 inch diameter.)



Gauge Length **G** to be not less than 4 times the diameter **D.**
With enlarged ends :—Parallel Length **P** to be not less than $4\frac{1}{2}$ times the reduced diameter **D.**

In some testing machines it was found inconvenient to use form **B** for bars of over 1 inch in diameter, and form **F** of half the gauge length is designed to meet such cases. For a given material the percentage of elongation with Test Piece **F** is greater than with Test Piece **B,** and this difference is provided for in the British Standard Specifications.

FORM OF ENDS.

In the case of the round Test Pieces **B, C, D, E** and **F,** the form of the ends is to be as required in order to suit the various methods employed for gripping the test piece. When enlarged ends are used the length of the parallel portion of the test piece must in no case be less than that noted on the diagrams.

British Engineering Standards Association.

PRICE LIST

OF

BRITISH STANDARD SPECIFICATIONS AND REPORTS.

NOVEMBER, 1919.

(This List cancels all previous Lists.)

NOTE.—*A number of the Publications of the Association are being issued in French, Italian, Spanish and Portuguese. The majority of the English Editions and all the foreign Translations (which also include the English text) are being published in two forms, and will be available at 1/- net per copy or its equivalent in Foreign moneys.*

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18-1910.	**Tensile Test Pieces,** Forms of	Gratis	-/2
21-1909.	**Pipe Threads** for Iron or Steel Pipes and Tubes, Report on ...	1/-	1/2
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	,, II. Locomotive, Carriage and Wagon Tyres	1/-	1/2
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35-1907.	**Copper Alloy Bars** for use in Automatic Machines, Specification for	1/-	1/2
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